PREFACE

The attention of scientific minds has long been drawn to the vast unexplored expanses in the vicinity of the North Pole.

Interest in this part of the globe was heightened after the celebrated Fram expedition—the first to raise the curtain on the scientific problems awaiting solution in the Central Arctic. Investigation of the great „blank spot" in the Central Polar Basin had become, as Nansen put it, a scientific necessity.

Method after method of studying the Central Arctic was suggested. Nansen was the originator of one of the most noteworthy of the projects for conducting these investigations. He suggested setting up, with the aid of dirigibles, a series of scientific stations on the drifting ice of the Polar Basin. But in spite of Nansen's high authority and prestige and the characteristic enthusiasm with which he advocated his idea, it proved impossible under the conditions of the time to gain sufficient support for the project.

After the October Revolution, when the Soviet Union began to undertake an investigation of the Arctic on a hitherto unprecedented scale and soon assumed incontrovertible primacy in this sphere of geographical science, the problems of the Central Arctic naturally claimed the interest of Soviet explorers, and Nansen's project did not of course escape their attention. To many the idea seemed fantastic, but the Soviet explorers set about preparing to carry it out with rare diligence and persistence, only slightly changing the technique: instead of a dirigible, they proposed to use a heavier-than-air machine to land the scientific expedition on the drift ice. In May 1937 the first drifting scientific station, under the direction of Ivan Papanin and known as the North Pole Station, was set up in the Central Arctic.

One of the conclusions to be drawn from this unique operation was that it was quite feasible, with the help of aircraft, to organize temporary scientific stations in any desired area of the Central Polar Basin, and thus in a comparatively short time to study the whole basin. This method of the „flying laboratory" seemed to open vast prospects for the exploration of the Central Arctic. But before adopting the method on a large scale it was thought expedient to put it to a thorough test by organizing an experimental expedition. This task was undertaken by the Arctic Institute. In March 1941 it fitted out an expedition to the Central Arctic on the aircraft USSR N-169 which was to make three landings for the purpose of scientific observation on the drift ice north of Wrangel Island, in the area known as the Pole of Relative Inaccessibility[1].

The expedition proved to be a complete success. Headed by I. I. Cherevichni, commander of the aircraft, and J. S. Libin, chief of scientific work, it not only demonstrated the practicability of the new method of exploring the Central Polar Basin, thus opening a new chapter in the study of the Arctic, but collected a great deal of valuable scientific material relating to an area of the globe which had hitherto not been visited by human beings. It is to the scientific work of the USSR N-169 expedition that this volume is dedicated.

All the articles in this book have been contributed by members of the expedition, with the exception of those examining synoptical conditions and describing the hydrobiological collections. The results of the gravitational observations will be published separately.

The hydrological observations are of exceptional interest. Six depth measurements made in the area of the Pole of Relative Inaccessibility disprove the idea that this region is the deepest part of the Polar Basin, an idea based on the echo-sounder measurement of 5,440 metres recorded by H. Wilkins at 77°46′ N, 185°E.

[1] The idea of a Pole of Relative Inaccessibility was introduced by Vilhjalmar Stefansson, who located its position at $\varphi = 83°50'$, $\lambda = 200°$.

The maximum depth sounded by the USSR N-169 expedition was only 3,370 metres. There is every reason to believe that Wilkins measurement was erroneous.

The expedition's observations revealed the same three principal water masses in the part of the Polar Basin adjacent to the Pole of Relative Inaccessibility as were found in other regions of the basin by the Fram, the Sedov and the North Pole Station, viz.: Polar (surface), Atlantic (intermediate) and deep water. Comparision of the observations of the USSR N-169 with those of other expeditions indicates that in the European sector of the Polar Basin the temperature of the Polar waters decreases from West to East, and that at the same time the thickness of the layer increases. The temperature of the Atlantic waters in the area of observation of the USSR N-169 was found to be lower, and the temperature of the deep waters higher than those in the region of the Fram and Sedov drifts. This is undoubtedly due to the progressive intermingling of the Atlantic waters with the underlying deep waters as the former slowly advances from the Greenland Sea into the Pacific part of the Polar Basin. The temperature of the deep waters, as the observations of the USSR N-169 expedition show, increases slightly in the bottom layer, which accords with the observations of the Fram and the North Pole Station.

Analysis of the drift of the three floes on which the N-169 landed shows that in the region of the Pole of Relative Inaccessibility we have the same constant surface current moving towards the Greenland Sea as was discovered by the Fram and Sedov. Determination of the elements of this current made on the basis of an analysis of the drift by Nansen's method revealed a direction of 292° and a velocity of 1.4 miles per day (24 hours); the results of an analysis made by Sverdrup's method (which is more reliable in this instance) are correspondingly 259° and 0.5 miles per day. The indexes of the wind drift of the ice according to the N-169's observations approximate very closely to those obtained from an analysis of the Maud's drift, viz.: angle of declination $\alpha = 31°$ (Maud, 33°); wind coefficient $\lambda.10^{-2} = 1.70$ (Maud, 1.77).

The observations of the N-169 expedition enable us to determine the velocity of the constant current in this part of the Polar Basin also by other methods, which on the whole yield similar results. Thus, at a depth of 25 metres, direct observations by means of an Eckman-Merz current meter determined the constant current, with allowance for wind and tidal currents, at a velocity of 2.3 miles per day and a direction of 273°, while a dynamic analysis of the deep-water observations of temperature and salinity resulted in determination of 1.8 miles per day and 284° respectively. The greater speed of the current at a depth of 25 metres as compared with the speed of the surface current (determined by an analysis of the ice drift) must be attributed to the friction of water against ice.

Direct current measurements made by the N-169 expedition also enable us to form a judgement of the elements of the tidal currents in the region of the Pole of Relative Inaccessibility. It is an interesting fact that the velocity of the diurnal tidal currents (maximum 6.3 centimetres per second) in this part of the Polar Basin is greater than the velocity of the semi-diurnal currents (4.0 centimetres per second). This fully accords with Nansen's observations of the tidal compression of the ice in the Polar Basin.

Noteworthy, too, are the observations made by the N-169 expedition of the state of the ice in the region of the Pole of Relative Inaccessibility. Pack-ice nowhere formed more than 80 per cent of the area, while the spaces between the pack-ice were filled not only with younger ice but in places even with open water. Open water spaces were particularly numerous in the area of the aircraft's third landing (80° N, 190° E), where they constituted about 10 per cent of the visible surface of the sea. The relatively large area of open water in the vicinity of the Pole of Relative Inaccessibility is apparently a phenomenon connected with the growing warmth of the Arctic climate, which in its turn is due to an intensified circulation of air and water masses. Under such circumstances the ice must move

with greater velocity from the Pacific and Alaskan sectors of the Polar Basin towards the Greenland Sea, as a result of which the discharge of pack-ice from this part of the Basin increases, leading to the appearance of areas of relatively young ice and even open water. An analysis of the meteorological observations made during the Sedov drift (1937—1940) led us at that time to the assumption that the centre of the rising warmth of the Arctic is located in the region of the Pole of Relative Inaccessibility. The observations of the N-169 expedition do not contradict this hypothesis.

The meteorological observations carried out at the landing spots of the USSR N-169 are only of relative value because of their short duration. Nevertheless, they are not without interest. They point to an extreme stability of the Arctic anticyclone in April in this part of the Polar Basin. Furthermore, comparision of the observations made at the ice camps of the N-169 with those made on Wrangel Island over a series of years permits the conclusion that the mean pressure for a number of years in the centre of the Arctic anticyclone in April is distinctly greater than was hitherto believed (by at least 5 mb compared, for instance, with the isobar chart compiled by Baur). It is interesting to note the relatively large amplitude of the diurnal variations of air temperature in April, which, according to the observations of the N-169 expedition, amounts in the region of the Pole of Relative Inaccessibility to about 5°. As we know, it is in April that this amplitude reaches its maximum in the Polar Basin.

Actinometrical observations carried out by the expedition show that in the vicinity of the Pole of Relative Inaccessibility total radiation (direct solar plus diffused) in April is very high, as was to be expected. The N-169 expedition was the first to make observations in the Central Polar Basin of the penetration of radiation through the ice and snow.

The magnetic work of the expedition consisted of absolute determinations of declination, horizontal component and inclination, as well as of observations of variation. Taken in conjunction with those of the North Pole drift station and the Sedov expedition, these observations furnish a fairly reliable basis for the construction of magnetic charts of the Central Polar Basin. The magnetic observations of the N-169 expedition confirm the scheme of symmetry of the magnetic field in the Northern Hemisphere suggested by B. P. Weinberg, as well as the hypothesis of the existence of a second magnetic pole. The expedition's observations of variation furnish additional proof that the diurnal fluctuations of the magnetic components in high altitudes is to some extent controlled by world time.

As to the hydrobiological collections of the expedition, only a description of the zooplankton specimens is given in this book. Prof. V. G. Bogorov proposes in another place to give a generalized summary of an examination of all the material gathered in the Polar Basin by all the Soviet expeditions.

This brief review of the principal scientific results obtained by the USSR N-169 expedition, which was experimental in character clearly demonstrates that the most effective method of studying the Central Polar Basin is by means of aircraft landings on the drifting ice. There can be no doubt but that this method will be widely employed in the Soviet Union, and that in this way the Central Arctic will be studied to the measure and degree demanded by science and practice.

W. Wiese

THE USSR N-169 EXPEDITION

J. S. Libin

SUMMARY

In the summer of 1940 the Arctic Institute submitted a memorandum to the Chief Administration of the Northern Sea Route recommending to send an expedition by airplane to the unexplored area of the Polar Basin with the purpose of investigating the region known as the Pole of Relative Inaccessibility, located between the 170th and 180th meridians and the 76th and 81th parallels. The plane was to make a series of landings on the ice at various points, each of a duration of not less than three days. At each landing spot astronomical, hydrological, meteorological, magnetic, gravitational, hydrobiological and actinometrical observations were to be carried out. In addition, it was to be the purpose of the expedition to investigate the possibility of employing new methods of exploration in high latitudes, methods which would be less restricted and more active than the drift of the Fram and the North Pole Station. The essential feature of these new methods was the direct use of aircraft as bases for expeditions carrying out a wide program of investigation.

The Arctic Institute's recommendations were approved in August 1940 and an airplane was assigned for the expedition. This was one of the planes which, in 1937, had flown to the North Pole and landed Papanin and his three companions on the ice to constitute the celebrated drifting expedition known as the North Pole Station. The airplane retained its original name: "USSR N-169".

Ten persons were selected for the expedition, which was headed by J. S. Libin, director of the Arctic Institute. I. I. Cherevichny, an experienced Arctic pilot, was commander of the plane.

The expedition was supplied with scientific instruments and equipment of reduced weight and dimensions, which is essential for air-borne expeditions.

The USSR N-169 took off from Moscow on March 5, 1941, and on March 20 reached Wrangel Island, having on the way investigated the condition of the ice from the Barents to the Chukchi Seas. Between April 2 and 29, three flights were made from Wrangel Island into the center of the Polar Basin and a landing was effected on the ice on each occasion.

In all, fifteen days were spent on the drifting ice. On May 5 the USSR N-169 took off from Wrangel Island for the return journey and arrived back in Moscow on May 11, again performing ice investigation on the way. From start to finish the plane had been in the air a total of 144 hours and flown a distance of 25,990 kilometers, most of it in regions of the Arctic which had never been visited by man before.

The times and locations of the three landings on the ice were as follows: 1) April 3, at 81°27′ N. 181°15′ E; 2) April 13, at 78°31′ N, 176°46′ E; 3) April 23, at 79°56′ N, 190°05′ E.

During each stay on the ice coordinates were determined at least once a day by the expedition's astronomer and magnetologist, M. E. Ostrekin, who also made the magnetic and gravity observations. In all, the coordinates of twenty points were determined.

Hydrological work performed by J. S. Libin and N. T. Chernigovsky in each camp included depth measurements, the taking of ground samples and water samples for the determination of salinity and oxygen content, and, lastly, diurnal observations of current at different depths. It was also the duty of the hydrologists to collect plankton.

Meteorological observations were made every three hours by the plane's navigator, V. I. Akkuratov, assisted by Chernigovsky. The latter also carried out observations of total and diffused solar radiation as well as the penetration of radiation through snow and ice.

The expedition secured valuable scientific data on the region of the Pole of Relative Inaccessibility:

1. Depth measurements revealed that ocean depths are far less than those that have hitherto figured on bathymetric maps.

2. A massive stratum of Atlantic water was found and it was ascertained that the stratification of the water mass in the area of investigation was similar to that observed in the areas of the North Pole Station and the Fram and Sedov expeditions.

3. There is a constant westerly current in the area of investigation.

4. The pack ice north of latitude 78° consitutes about 80 per cent of the total surface.

5. W. Wiese's conjecture that loose ice would be encountered in the region of the Pole of Relative Inaccessibility was corroborated. Between the pack fields there were spaces of younger ice and even of open water.

6. Meteorological observations indicate the existence of an extremely stable anticyclone in April.

7. Magnetic observations made it possible to correct the magnetic charts of the Central Arctic and confirmed Weinberg's hypothesis of the existence of a second magnetic pole (the Sedov pole) and the symmetry of the magnetic field in the Northern Hemisphere.

8. It was ascertained that as regards the animal kingdom the region of the Pole of Relative Inaccessibility is not uninhabited. At the second ice camp a bear appeared and the tracks of a polar fox were seen.

9. No unknown land was found anywhere on the route of the USSR N-169 in these areas.

It may be said that this method of exploring the Central Polar Basin with the help of an aircraft is fully adapted to the carrying out of broadly complex scientific programs. While the method of drift, such as was employed by the Fram and the North Pole Station, should not be discarded, aircraft will undoubtedly become the chief means of investigating these regions in future. It permits greater freedom in the choice of points of investigation, it is more simple in respect to the organization of stations on the drifting ice, and it has the additional advantage of greater cheapness.

The method should be employed systematically from year to year, and not only for the exploration of "blank spots," but also for the making of standard cross-sections of already investigated areas. Drawing on the experience of the USSR N-169 expedition, it should be possible considerably to widen our knowledge of the Central Polar Basin in a relatively short time.

Such expeditions should have more than one plane. Three or four craft, based at different points, could in the course of the spring months make a large number of landings on the drifting ice and embrace a considerably larger area than that which the USSR N-169 was able to cover.

A number of questions arose. What sort of ice could we expect to encounter at the landing points? How could we determine from the air whether the ice would be suitable for landing? Should the engines be cut out on landing or allowed to run? These and similar questions led me to select the ice-floes with great care. Previous experience had shown that when the sun is shining the shadows even of small hummocks are visible from aloft and that ice ridges can also be made out. In dull weather, when the sun is hidden, the surface of ice fields seems absolutely smooth—all unevennesses become indistinct. Landing in dull weather is a very dangerous proceeding. Our third landing was made on a cloudy day, the ice-floe selected proved to be rather rough and we slightly damaged our plane skis. The whole expedition had to work hard to make a runway. The hard uneven snow surface had to be dug over and smoothed out on an area of 600×20 metres. Taking off from such a runway with damaged skis was no light undertaking.

We returned to Wrangel Is. on April 29, having fully completed our contemplated program of scientific work in the region of the Pole of Relative Inaccessibility.

The expedition on the USSR N-169 demonstrated the complete feasibility of Arctic exploration with the help of "flying laboratories". All the "blank spots" in the Polar Basin can be studied in a comparatively short period, especially if several aircraft are used for the purpose.

WHERE MAN HAD NOT SET FOOT BEFORE

I. I. Cherevichny

SUMMARY

The idea of organizing scientific stations on the drifting ice of the Polar Basin with the help of aircraft-laboratories had occurred to many Arctic explorers. It was the good fortune of myself and my colleagues of the USSR N-169 expedition to carry this idea into practical effect in the region of the Pole of Relative Inaccessibility. As a first preparatory step in this direction, during my annual summer air reconnaissances of ice conditions I made deep excursions into the Polar Basin. For instance, in 1939, on the N-275, I explored the area northeast of Henrietta Island as far as 79°N, 166° E, and in the summer of 1940, on the same plane, investigation was carried to 82°N, 170°E. These two flights revealed that in the reconnoited areas ice-floes were to be found on which an aircraft could be landed. In January 1941 the Chief Administration of the Northern Sea Route approved a project of the Arctic Institute for a scientific expedition to be landed on the ice from the air.

The USSR N-169 was assigned for this purpose, a capacious plane which had proved its worth in many an Arctic flight. It had been used in 1937 to land the celebrated Papanin expedition on the ice at the North Pole. Our expedition was to fly from Wrangel Is. to the region of the Pole of Relative Inaccessibility and make three landings on the drifting ice for the purpose of scientific observations.

The USSR N-169 was re-adapted for prolonged cruising without contact with air bases. It was fitted up with the conveniences of a traveling home and even had a kitchen. We were only dependent on the mainland for fuel and oil for the plane's engines. During the stays on the ice the entire staff of the expedition, the scientific group and crew alike, were motivated by one single purpose—to carry out a maximum amount of scientific work in the brief time at our disposal. Some of the crew helped with the scientific observations, others performed fatigue duties. The mechanics, for instance, helped the hydrologists, the navigator did the meteorological observations, while the second pilot performed the duties of cook and wireless man kept us in contact with the outer world.

It was a feature of our expedition that we had no preliminary information about conditions in the area of the contemplated landings. The two earlier flights of the N-275 had been to an adjacent region and observations were only made from the air.

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